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PATENT & TRADEMARK OFFICE

Docket No.: 392.1682

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re the Application of:

Atsushi WATANABE et al.

Serial No. 09/546,213 Group Art Unit: 2625

Confirmation No. 3616

Filed: April 10, 2000 Examiner: Manav Seth

For: TEACHING MODEL GENERATING DEVICE

APPEAL BRIEF

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

CERTIFICATE UNDER 37 CFR 1.8(a)
I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, PO. Box 1450, Alexandria, VA 22313-1450 on 9-11 2006
STAAS & HALSEY
By [signature]
Date Sept 11, 2006

Sir:

I. Real Party in Interest

The inventors Atsushi Watanabe and Taro Arimatsu assigned all rights in the subject application to FANUC LTD. on April 24, 2000 according to the Assignment executed April 24, 2000 and submitted for recordation on June 7, 2000. Therefore, the real party in interest is FANUC LTD.

II. Related Appeals and Interferences

There are no related appeals or interferences known to Appellants, Appellants' legal representatives or the Assignee, FANUC LTD., which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

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III. Status of Claims

Claims 1-14 are pending in the application and claims 1-14 stand rejected under 35 USC § 103(a).

IV. Status of Amendments

No Amendment was filed in response to the March 13, 2006 Office which stated that the Amendment filed by Certificate of Mailing on January 9, 2006 and received by the U.S. Patent and Trademark Office on January 11, 2006 was entered.

V. Summary of Claimed Subject Matter

The present invention is directed to using a robot for generating "teaching models" used to detect "an object regardless of three-dimensional variations in position and posture of the object" (page 1, lines 8-10). This is accomplished by capturing images of a reference object, according to different directions, orientations, positions, arrangements, etc. (page 3, lines 7-12). For example, four teaching models are generated based on image data obtained for the workpiece W viewed from four directions, as illustrated in Fig. 4 (page 6, lines 11-13). Image processing device 30 (Fig. 6) calculates information regarding the relative position and posture of the camera to the workpiece when the image was taken (page 14, last 3 lines and page 15, lines 1-7). The position and posture information is stored in non-volatile memory 37 with the image data which are used to automatically determine orientations of objects (workpieces) with shapes similar or identical to the reference object (page 16, lines 2-4).

Claim 1 recites a "teaching model generating device for image processing, in which a subject object has the same or substantially similar shape as that of a reference object" (claim 1, lines 1-2). One example of this in the specification is image processing device 30 (Fig. 6), as briefly described at page 8, lines 10-11.

Next, claim 1 recites

> an image processing system with which a current three-dimensional orientation of the subject object relative to an image pickup device is recognized by carrying out pattern matching processing of an image of the subject based on a plurality of pre-determined teaching models of the reference object

(claim 1, lines 3-6). For example, as described on pages 22-23, image processing device 30 (Fig. 6) performs operation 403 in Fig. 10.

Prior to the operations performed by the image processing system recited on lines 3-6 of claim 1, "an image-capture system ... [generates and stores] the plurality of teaching models on the basis of respective image data produced by taking images of said reference object from a plurality of directions" (claim 1, lines 7-9). As described at page 17, line 1 to page 18, line 14, image processing system 30 (Fig. 6) can be used to perform the operations recited as being performed by the image-capture system.

The operations performed by the image-capture system are further defined in claim 1 in that "one of the reference object and said image pickup device is fixed to a movable and positionable part of a robot or is grasped with a hand of the robot, and said robot is operated for positioning to a plurality of different image pickup positions and directions" (claim 1, lines 9-12). In a first embodiment described on pages 6-15, the camera is moved by the robot, as illustrated in Fig. 1. In a second embodiment described on pages 16-18, the camera is fixed in position and the robot moves the object, as illustrated in Fig. 3. In the third embodiment described on pages 18-21, both the object and the camera are mounted on the end of a robot arm and may be moved, as illustrated in Fig. 3.

Claim 1 ends by reciting that "the image data respectively obtained at each of said different image pickup positions and direction information indicating the respective different direction, is stored as a teaching model" (claim 1, last 3 lines). This is described for each of the first through third embodiments, including at page 16, lines 2-4.

The preamble of claim 2 is identical to that of claim 1 and therefore also has an example described at page 8, lines 10-11. Similarly, lines 3-6 of claim 2 are the same as lines 3-6 of claim 1 and thus, the example described on pages 22 and 23 of image processing device 30 (Fig. 6) performing operation 403 in Fig. 10 applies to these lines of claim 2. In addition, claim 2 recites ""an image-capture system ... generating and storing the plurality of teaching models on the basis of respective image data produced by taking images of said reference object from a plurality of directions" (claim 2, lines 7-9) using the same words as claim 1. Thus, the description of image processing system 30 (page 17, line 1 to page 18, line 14; Fig. 6) as an example of the image-capture system applies to claim 2 also.

The details recited on lines 9-15 of how the image-capture system recited in claim 2 operates are different than in claim 1. Claim 2 recites "the reference object is fixed to a movable part of a first robot or is grasped with a hand of the first robot, and said image pickup device is fixed to a movable and positionable part of a second robot or is grasped with a hand of the second robot" (claim 2, lines 9-12) and thus, the third embodiment described on pages 18-21 with reference to Fig. 3 applies to claim 2. In addition, "any one of or both of said first and second robots is operated for positioning to a plurality of different relative image pickup positions and directions, so that the image data respectively obtained at each of said different image pickup positions is stored as a teaching model" (claim 2, last 4 lines) and thus, the operations described with respect to the first and second embodiments on pages 6-18 with reference to Figs. 1 and 2 also apply to claim 2.

Claim 8 is directed to a "method for teaching model generation and image processing" (claim 8, line 1). Examples of teaching model generation methods for each of the first through third embodiments are illustrated in Figs. 7-9 which are described on pages 6-21. As noted above, an example of an image processing method is illustrated in Fig. 10 and described on pages 22-23.

The first operation recited in claim 8 is "determining a current three-dimensional orientation of a subject object relative to an image pickup device by carrying out pattern matching processing of an image of the subject based on a plurality of predetermined teaching models of a reference object" (claim 8, lines 2-4). The description of operations 403-406 in Fig. 10 at page 22, line 19 to page 23, line 3 is an example of the determining operation recited on lines 2-4 of claim 8.

The second operation recited in claim 8 is "generating and storing the plurality of teaching models on the basis of respective image data produced by taking images of said reference object from a plurality of directions" (claim 8, lines 5-7) which is performed "in advance of the determining" (claim 8, line 5). As noted above with respect to the same words in claim 1, examples of this operation are described on pages 6-21.

The details of how the second operation of claim 8 is performed are recited on lines 9-14 of claim 8, where "one of the reference object and said image pickup device is fixed to a movable and positionable part of a robot or is grasped with a hand of the robot" (claim 8, lines 9-11) and "said robot is operated for positioning to a plurality of different image pickup positions and directions" (claim 8, lines 11-12) as described in the first through third embodiments on pages 6-21 and illustrated in Figs. 1-3, as discussed above with respect to claim 1. Finally, "the image data respectively obtained at each of said different image pickup positions and direction information indicating the respective different direction, is stored as a teaching model" (claim 8, last 3 lines), as described at page 16, lines 2-4 for the first embodiment, page 18, lines 10-14 with reference to blocks 204-208 in Fig. 8 for the second embodiment and page 21, last 5 lines with reference to blocks 305-310 in Fig. 9 for the third embodiment.

Claim 9 is directed to a "method of automatic orientation recognition" (claim 9, line 1). All of the inventive methods described in the specification are examples of "automatic orientation recognition".

Examples of the first operation recited in claim 9, "generating and storing a set of images of different relative orientations of a subject" are described in each of the first through third embodiments on pages 6-21, as discussed above. The further details recited as "the images

having been captured by a plurality of robotic operations corresponding to the different relative orientations of the subject, and associating with each image information indicating its respective relative orientation of the subject" (claim 9, lines 2-5) apply to all of the first through third embodiments where one or both of the camera and the reference object are moved by a robot arm.

An example of the second operation of claim 9, "capturing a current image of a work-piece that has an unknown orientation relative to an image pickup device on the robot before the robot has come into contact with the workpiece, where the workpiece has a shape substantially similar to the shape of the subject" (claim 9, lines 6-9) which is performed "from a known current orientation of a robot" (claim 9, line 6), is described at page 22, lines 15-18 with reference to operation 402 in Fig. 10.

An example of the third operation of claim 9, "using pattern matching to match one of the stored images with the current image" (claim 9, lines 10-11) is described at page 22, line 19 to page 23, line 10 with reference to operations 403-407 in Fig. 10.

An example of the final operation of claim 9, "determining the orientation of the work-piece relative to the image pickup device on the robot based on the relative orientation information associated with the matched stored image, and also based on the known current orientation of the robot" (claim 9, last 3 lines) "after the pattern matching, and before the robot has come into contact with the workpiece" (claim 9, lines 12-13) is described in the paragraph spanning pages 23 and 24 with reference to operation 409 in Fig. 10.

Like claim 9, claim 12 is directed to a "method of automatic orientation recognition" claim 12, line 1) and therefore, all of the embodiments are examples of the method recited in claim 12.

The first operation recited in claim 12,

> generating and storing a set of images of different relative arrangements of a subject, the images having been captured by a plurality of robotic operations corresponding to the different relative arrangements and associating with each image information indicating its respective relative arrangement of the subject

(claim 12, lines 4-5) is consistent with how each of the first through third embodiments are described as obtaining image data of a reference object. Thus, the descriptions of the embodiments on pages 6-21 which are discussed above, apply to claim 12.

An example of the second operation recited in claim 12, "with a known current arrangement of an image pickup device on a robot, capturing a current image of a workpiece with an unknown current arrangement relative to the robot, where the workpiece has a shape

substantially similar to the shape of the subject" (claim 12, lines 6-8) is described at page 22, lines 15-18 with respect to operation 402 in Fig. 10.

An example of the third operation recited in claim 12, "using pattern matching to match one of the stored images with the current image" (claim 12, line 9) is described at page 22, line 19 to page 23, line 10 with reference to operations 403-407 in Fig. 10.

An example of the final operation recited in claim 12, "determining the current orientation of the workpiece relative to the image pickup device on the robot based on the relative arrangement information associated with the matched stored image, and also based on the known current arrangement of the image pickup device on the robot" (claim 12, last 4 lines) is described in the paragraph spanning pages 23 and 24 with reference to operation 409 in Fig. 10.

The preamble of claim 13 does not include any details of the invention. An example of the first operation recited in claim 13, "robotically taking images of a subject with different three-dimensional subject-camera arrangements that vary in three dimensions, and associating with each image or data thereof information indicating its subject-camera arrangement" are described in each of the first through third embodiments on pages 6-21, as discussed above.

An example of the second operation recited in claim 13, "taking a current image of a workpiece shaped like the subject" (claim 13, line 5) is described at page 22, lines 15-18 with reference to operation 402 in Fig. 10.

An example of the third operation recited in claim 13, "determining a current workpiece-camera orientation by matching one of the images or data thereof with the current image" (claim 13, lines 7-8) "before picking up the workpiece" (claim 13, lines 5-6) is described at page 22, line 19 to page 23, line 10 with reference to operations 403-407 in Fig. 10.

An example of the final operation recited in claim 13, "using predetermined subject-camera arrangement information of the matched image to determine the three-dimensional orientation of the workpiece relative to the camera" (claim 13, last 3 lines) is described in the paragraph spanning pages 23 and 24 with reference to operation 409 in Fig. 10.

Claim 14 is directed to at "least one computer-readable medium storing instructions that when executed control a robot apparatus to perform a method" (claim 14, lines 1-2). As stated in the sentence spanning pages 6 and 7 of the specification, an "operation program and its related set data of the robot taught according to an application are stored in the non-volatile memory of the memory 2" illustrated in Fig. 5.

An example of the first operation of the method recited in claim 14 as being performed when the instructions in the computer-readable medium are executed, "robotically taking images of a subject with a camera in different subject-camera arrangements varying in three dimensions" is described in each of the first through third embodiments on pages 6-21, as discussed above.

An example of the second operation of the method recited in claim 14 as being performed when the instructions in the computer-readable medium are executed, "associating with each image, information indicating an obtaining subject-camera arrangement used in obtaining the image" (claim 14, lines 5-6) described, for example, in the paragraph spanning pages 23 and 24 with reference to operation 409 in Fig. 10.

An example of the third operation of the method recited in claim 14 as being performed when the instructions in the computer-readable medium are executed, "after said associating of the images, taking a current image of a workpiece shaped like the subject" (claim 14, lines 7-8) is described at page 22, lines 15-18 with reference to operation 402 in Fig. 10.

An example of the fourth operation of the method recited in claim 14 as being performed when the instructions in the computer-readable medium are executed, "determining a current workpiece-camera orientation by matching one of the images with the current image and using the information indicating the obtaining subject-camera arrangement associated with the one of the images" (claim 14, lines 9-11) is described at page 22, line 19 to page 23, line 10 with reference to operations 403-407 in Fig. 10.

An example of the final operation of the method recited in claim 14 as being performed when the instructions in the computer-readable medium are executed, "picking up the workpiece after said determining" is described at page 24, lines 3-6 with reference to the operation 410 in Fig. 10.

VI. Grounds of Rejection to be Reviewed on Appeal

In the final Office Action dated March 13, 2006, the Examiner rejected claims 1, 3, 4, and 8-14 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Patent 4,462,046 to Spight in view of U.S. Patent 5,745,387 to Corby, Jr. et al.; claims 2, 5 and 6 were rejected as unpatentable over Spight in view of Corby, Jr. et al. and further in view of U.S. Patent 4,504,970 to Werth et al.; and claim 7 was rejected as unpatentable over Spight in view of Corby, Jr. et al. and Werth et al. and further in view of U.S. Patent 4,611,292 to Ninomiya et al. At issue is whether Spight in view of Corby, Jr. et al., Werth et al. and Ninomiya et al. teach or suggest all of

the limitations recited in the claims and what motivation there is to combine the teachings of these references, particularly Spight and Corby, Jr. et al..

VII. Argument

In item 5 on pages 3-8 of the March 13, 2006 Office Action, claims 1, 3, 4, and 8-14 were rejected under 35 U.S.C. § 103 as being unpatentable over Spight in view of Corby, Jr. et al. In rejecting claims 1 and 8, it was asserted that Spight "discloses that in order to produce real-time identification and determination of location and orientation of parts (object), a viewed representation of the object is compared (pattern matching) with a stored representation of the desired objects" (March 13, 2006 Office Action, page 3, last 3 lines and page 4, line 1, original emphasis removed) and from this "disclosure by Spight, it is clear that the stored image data is nothing but a plurality of teaching models" (March 13, 2006 Office Action, page 4, lines 2-3).

In addition, it was acknowledged that Spight does not teach that "said robot is operated for positioning to a plurality of different image pickup positions and directions" (e.g., claim 1, lines 11-12) to obtain "the image data ... stored as a teaching model" (e.g., claim 1, last 3 lines), but it was asserted that Corby, Jr. et al. can be combined with Spight to provide this feature of the claimed invention. It is submitted that insufficient evidence has been cited to support a finding that one of ordinary skill in the art would find it obvious to combine the teachings of Spight and Corby, Jr. et al.

No statement has been found in the March 13, 2006 Office Action regarding what would motivate one of ordinary skill in the art to combine the teachings of Spight and Corby, Jr. et al., let alone, "[e]xplicit findings on motivation or suggestion to select the claimed invention ... to support a 35 U.S.C. 103 ground of rejection" as required in MPEP 2144.08. It is well established by case law that "[t]he factual inquiry whether to combine references ... must be based on objective evidence of record. ... [The] factual question of motivation ... cannot be resolved on subjective belief and unknown authority." *In re Lee*, 277 F.3d 1338, 1343-4, 61 USPQ2d 1430 (Fed. Cir. 2002).

The only statements that have been found in the March 13, 2006 Office Action that come close to suggesting a motivation to combine Spight and Corby, Jr. et al. are that

> it would have been obvious to one of ordinary skill in the art at the time the invention was made to fix an image pickup device to a movable and positionable part of a robot, operate the robot for positioning to a plurality of different image pickup positions and directions, and store direction information indicating the respective different direction[s] with the image data as a teaching model as taught by Corby in order to define the identity of the site imaged, when it was imaged, the viewpoint, the modality of the imager and description of values relating to the image ...

> and … to further enhance the object identification when [the] object is viewed at different directions or viewpoints, keeping in view the 3 dimensional structure of the object, in real-time and further both references are directed to robotic industrial automation

(March 13, 2006 Office Action, page 5, last line to page 6, line 9). With the exception of the statement that "both references are directed to robotic industrial automation", all that seems to be described is what the Examiner asserted one of ordinary skill in the art would learn from Corby, Jr. et al. No reason was provided for why this would motivate one of ordinary skill in the art to combine the teachings of Corby, Jr. et al. with those of Spight. The mere fact that "both references are directed to robotic industrial automation" is insufficient. Examiners are required to "explain the reasons one of ordinary skill in the art would have been motivated to select the references." *In re Lee*, 61 USPQ2d at 1434. "Obviousness can not be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching, suggestion or incentive supporting the combination." *In re Gorman*, 933 F2d 982, 18 USPQ2d 1885, 1888 (Fed. Cir. 1991) quoting *In re Bond*, 910 F2d 831, 834, 15 USPQ2d 1566, 1568 (Fed. Cir. 1990) which in turn quoted *Carella v. Starlight Archery and Pro Line Co.*, 804 F.2d 135, 140, 231 USPQ 644, 647 (Fed. Cir. 1986).

There is nothing on the record to explain what advantage would be gained by combining Corby, Jr. et al. with Spight. The mere fact that Corby, Jr. et al. discloses a conventional positioning of a camera by a robot arm and the claimed invention can also use such an arrangement does not provide a reason for modifying Spight. Rather, the rejection of the claims over the combination of Spight and Corby, Jr. et al. suggests that impermissible hindsight has been used to find a reference (Corby, Jr. et al.) which discloses features of the invention that are missing from Spight without providing a reason for a person of ordinary skill in the art to combine the teachings of these references.

Item 10 on pages 11-12 of the March 13, 2006 Office Action responded to the arguments in the January 9, 2006 Amendment that the Background of the Invention section in Corby, Jr. et al. teaches away from using Corby, Jr. et al. to modify Spight or that Corby, Jr. et al. is relevant to the invention, since neither Spight nor the invention are directed to operations in "environments which are inaccessible or very hazardous for humans" or "to determine the rate of deterioration" as in Corby, Jr. et al. In this response, it was asserted that the "Examiner does not rely on Corby to provide teachings on the hazardous environments for humans" (March 13, 2006 Office Action, page 12, lines 4-5). It is submitted that why the Examiner is relying on Corby, Jr. et al. is not the test for whether one of ordinary skill in the art would find it obvious to combine Corby, Jr. et al. and Spight. The issue is whether the entirety of the teachings in Corby, Jr. et al. and Spight

would lead one of ordinary skill in the art to combine Corby, Jr. et al. and Spight. It is submitted that the fact that Corby, Jr. et al. is concerned with hazardous environments for humans and Spight is not is relevant to determining the issue of obviousness to combine their teachings.

Further, contrary to the implication at page 12, lines 15-17 of the March 13, 2006 Office Action that Corby, Jr. et al. discloses "pattern matching" by a processor, as that term is used in the application, as discussed in the January 9, 2006 Amendment there is no suggestion in Corby, Jr. et al. of storing a plurality of views for the purpose of **identifying** anything. The archive and comparison device taught by Corby, Jr. et al. is used for determining deterioration at a given inspection site, not for identification. No description has been cited or found in Corby, Jr. et al. regarding how an operator determines what file should be used for comparison. Presumably the typical technique of using a naming convention for the files would be used, since other textual data can be input via text input device 57 (see column 6, lines 41-51). There is not the slightest suggestion that the site where deterioration is occurring is identified "by carrying out pattern matching processing of an image" (claim 1, lines 5-6), either automatically, or by an operator. Rather, Corby, Jr. et al. merely describes recording images of a site from various viewpoints and providing the images for comparison by a human operator.

The lack of similarity in how the images are used in Corby, Jr. et al. and Spight is an additional reason why one of ordinary skill in the art would not find it obvious to combine Corby, Jr. et al. and Spight. The automatic processing of images taught by Spight is significantly different from the human comparison of images taught by Corby, Jr. et al. For all of the above reasons, it is submitted that claims 1, 8, 9 and 12-14, as well as claims 3, 4, 10 and 11 which depend therefrom, patentably distinguish over the applied art.

In item 6 on pages 8-10 of the March 13, 2006 Office Action, claims 2, 5 and 6 were rejected under 35 U.S.C. § 103 as being unpatentable over Spight in view of Corby, Jr. et al. and further in view of Werth et al. In item 7 on page 10 of the Office Action, claim 7 was rejected as unpatentable over Spight in view of Corby, Jr. et al. and Werth et al. and further in view of Ninomiya et al. Nothing has been cited or found in Werth et al. or Ninomiya et al. suggesting modification of the combination of Spight and Corby, Jr. et al. to overcome the deficiencies discussed above. Therefore, it is submitted that claims 2 and 5-7 patentably distinguish over Spight in view of Corby, Jr. et al., Werth et al. and Ninomiya et al. for at least the reasons set forth above with respect to claim 1 from which they depend.

Summary of Arguments

For the reasons set forth above and in the Response filed April 14, 2005 and the Amendment filed January 9, 2006, it is submitted that claims 1-14 patentably distinguish over Spight, Corby, Jr. et al., Werth et al. and Ninomiya et al. Thus, it is respectfully submitted that the Examiner's final rejection of the claims is without support and, therefore, erroneous. Accordingly, the Board of Patent Appeals and Interferences is respectfully urged to so find and to reverse the Examiner's final rejection.

The required fee in the amount of $500.00 is attached. If any additional fees are required, please charge same to our Deposit Account No. 19-3935.

Respectfully submitted,

STAAS & HALSEY LLP

Date: 9/11/06

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VIII. Claims Appendix

1. A teaching model generating device for image processing, in which a subject object has the same or substantially similar shape as that of a reference object, the device comprising:

an image processing system with which a current three-dimensional orientation of the subject object relative to an image pickup device is recognized by carrying out pattern matching processing of an image of the subject based on a plurality of pre-determined teaching models of the reference object; and

an image-capture system, in advance of the recognizing, generating and storing the plurality of teaching models on the basis of respective image data produced by taking images of said reference object from a plurality of directions, wherein one of the reference object and said image pickup device is fixed to a movable and positionable part of a robot or is grasped with a hand of the robot, and said robot is operated for positioning to a plurality of different image pickup positions and directions, so that the image data respectively obtained at each of said different image pickup positions and direction information indicating the respective different direction, is stored as a teaching model.

2. A teaching model generating device for image processing, in which a subject object has the same or substantially similar shape as that of a reference object, the device comprising:

an image processing system with which a current three-dimensional orientation of the subject object relative to an image pickup device is recognized by carrying out pattern matching processing of an image of the subject based on a plurality of pre-determined teaching models of the reference object; and

an image-capture system, in advance of the recognizing, generating and storing the plurality of teaching models on the basis of respective image data produced by taking images of said reference object from a plurality of directions, wherein the reference object is fixed to a movable part of a first robot or is grasped with a hand of the first robot, and said image pickup device is fixed to a movable and positionable part of a second robot or is grasped with a hand of the second robot, and any one of or both of said first and second robots is operated for positioning to a plurality of different relative image pickup positions and directions, so that the image data respectively obtained at each of said different image pickup positions is stored as a teaching model.

3. A teaching model generating device according to claim 1, wherein said teaching model is a part of the image data of the reference object.

4. A teaching model generating device according to claim 1, wherein said teaching model comprises data obtained by performing image processing on the image data of the reference object.

5. A teaching model generating device according to claim 2, wherein said teaching model is generated for every direction in which said image pickup device took the image of said reference object and said teaching model is stored in association with information on the direction.

6. A teaching model generating device according to claim 2, wherein said image pickup device is a camera.

7. A teaching model generating device according to claim 2, wherein said image pickup device is a three-dimensional visual sensor that measures a distance between the image pickup device and a plurality of points on the object.

8. A method for teaching model generation and image processing, comprising:

determining a current three-dimensional orientation of a subject object relative to an image pickup device by carrying out pattern matching processing of an image of the subject based on a plurality of predetermined teaching models of a reference object; and

in advance of the determining, generating and storing the plurality of teaching models on the basis of respective image data produced by taking images of said reference object from a plurality of directions, wherein one of the reference object and said image pickup device is fixed to a movable and positionable part of a robot or is grasped with a hand of the robot, and said robot is operated for positioning to a plurality of different image pickup positions and directions, so that the image data respectively obtained at each of said image pickup positions and direction information indicating the respective different direction, is stored as a teaching model.

9. A method of automatic orientation recognition, comprising:

generating and storing a set of images of different relative orientations of a subject, the images having been captured by a plurality of robotic operations corresponding to the different relative orientations of the subject, and associating with each image information indicating its respective relative orientation of the subject;

after the generating and storing, from a known current orientation of a robot, capturing a current image of a workpiece that has an unknown orientation relative to an image pickup device on the robot before the robot has come into contact with the workpiece, where the workpiece has a shape substantially similar to the shape of the subject;

after the capturing, using pattern matching to match one of the stored images with the current image; and

after the pattern matching, and before the robot has come into contact with the workpiece, determining the orientation of the workpiece relative to the image pickup device on the robot based on the relative orientation information associated with the matched stored image, and also based on the known current orientation of the robot.

10. A method according to claim 9, further comprising automatically maneuvering the robot to the workpiece based at least on the determined orientation of the workpiece relative to the robot.

11. A method according to claim 9, wherein the generating and storing is performed for a plurality of differently shaped subjects, wherein the current image includes a plurality of differently shaped workpieces, and wherein the pattern matching further comprises identifying the workpiece from among the plurality of differently shaped workpieces using the images and orientation information of the plurality of differently shaped subjects.

12. A method of automatic orientation recognition, comprising:

generating and storing a set of images of different relative arrangements of a subject, the images having been captured by a plurality of robotic operations corresponding to the different relative arrangements, and associating with each image information indicating its respective relative arrangement of the subject;

with a known current arrangement of an image pickup device on a robot, capturing a current image of a workpiece with an unknown current arrangement relative to the robot, where the workpiece has a shape substantially similar to the shape of the subject;

using pattern matching to match one of the stored images with the current image; and

determining the current orientation of the workpiece relative to the image pickup device on the robot based on the relative arrangement information associated with the matched stored image, and also based on the known current arrangement of the image pickup device on the robot.

13. A method, comprising:

robotically taking images of a subject with different three-dimensional subject-camera arrangements that vary in three dimensions, and associating with each image or data thereof information indicating its subject-camera arrangement; then

taking a current image of a workpiece shaped like the subject; and then before picking up the workpiece

determining a current workpiece-camera orientation by matching one of the images or data thereof with the current image, and using predetermined subject-camera arrangement information of the matched image to determine the three-dimensional orientation of the workpiece relative to the camera.

14. At least one computer-readable medium storing instructions that when executed control a robot apparatus to perform a method comprising:

robotically taking images of a subject with a camera in different subject-camera arrangements varying in three dimensions;

associating with each image, information indicating an obtaining subject-camera arrangement used in obtaining the image;

after said associating of the images, taking a current image of a workpiece shaped like the subject;

determining a current workpiece-camera orientation by matching one of the images with the current image and using the information indicating the obtaining subject-camera arrangement associated with the one of the images; and

picking up the workpiece after said determining.

IX. Evidence Appendix

(None)

X. Related Proceedings Appendix

(None)